Real-Time Mantra

Pass the positions, NOW!!

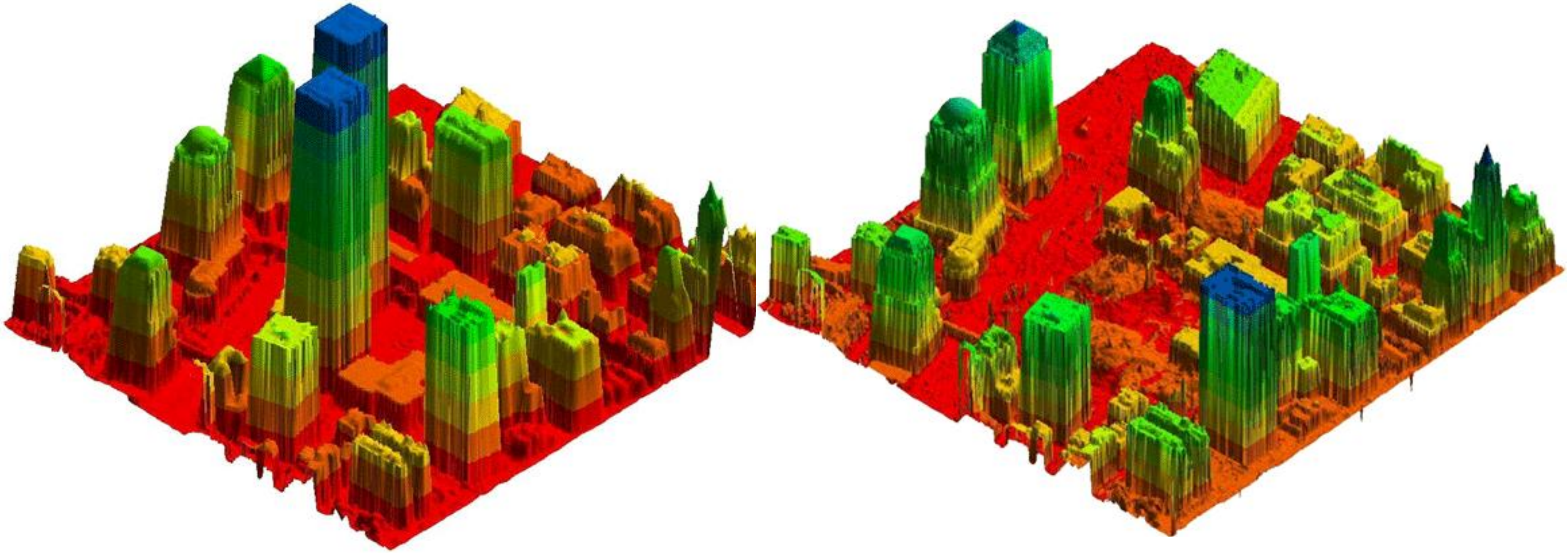
Applications for 1- 5 cm Real-Time Positioning

- Land surveying
- Remote sensing / photogrammetry
- Hydrography
- Machine control (construction, precision agriculture)
- Emergency response
- Asset inventory

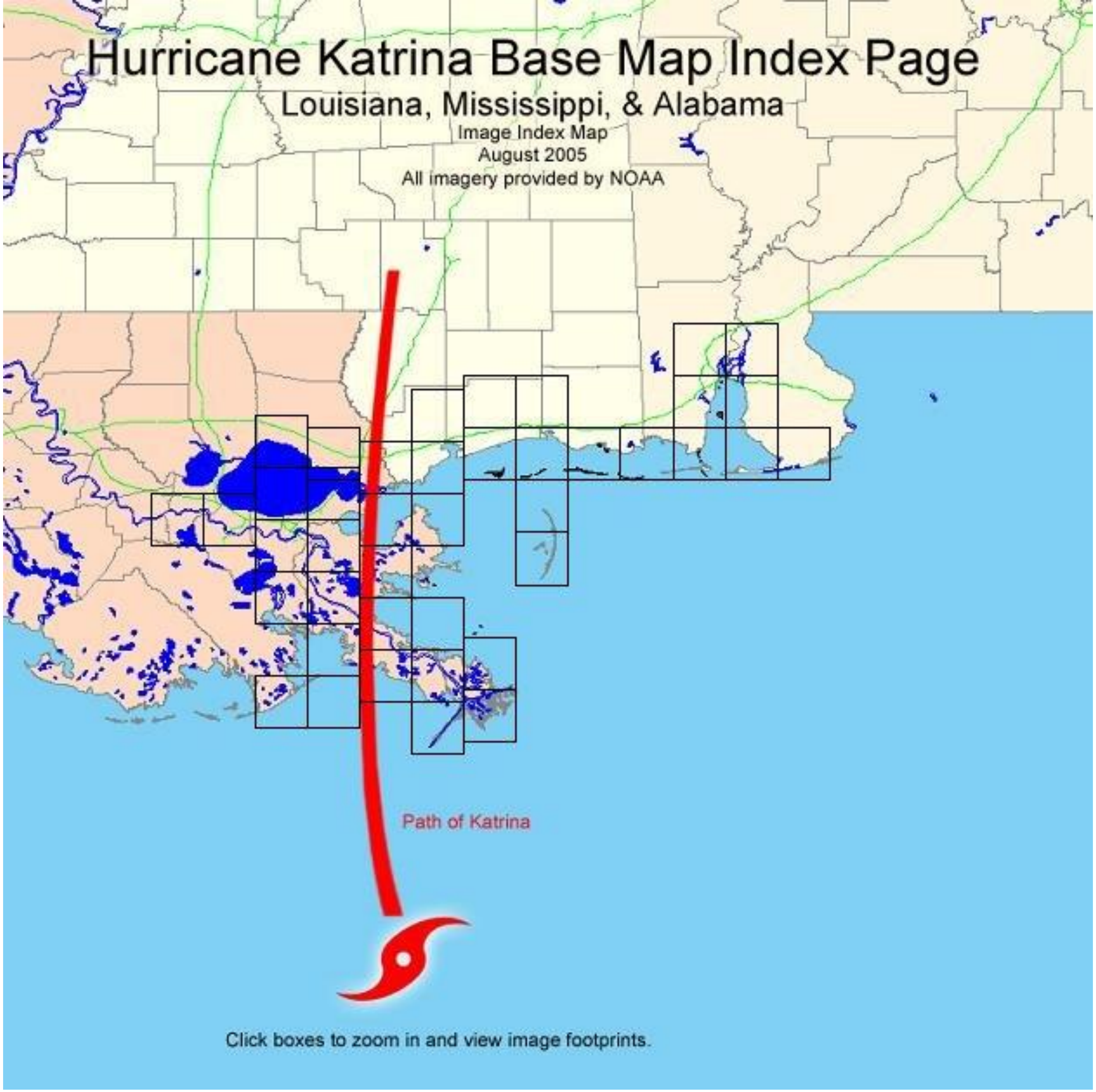
Real-Time Applications (continued)

- Structural integrity monitoring (dams, bridges, critical facilities)
- Atmospheric monitoring (ionospheric & tropospheric modeling, weather forecasting)
- Tsunami & volcanic warning system (detecting seismic waves)

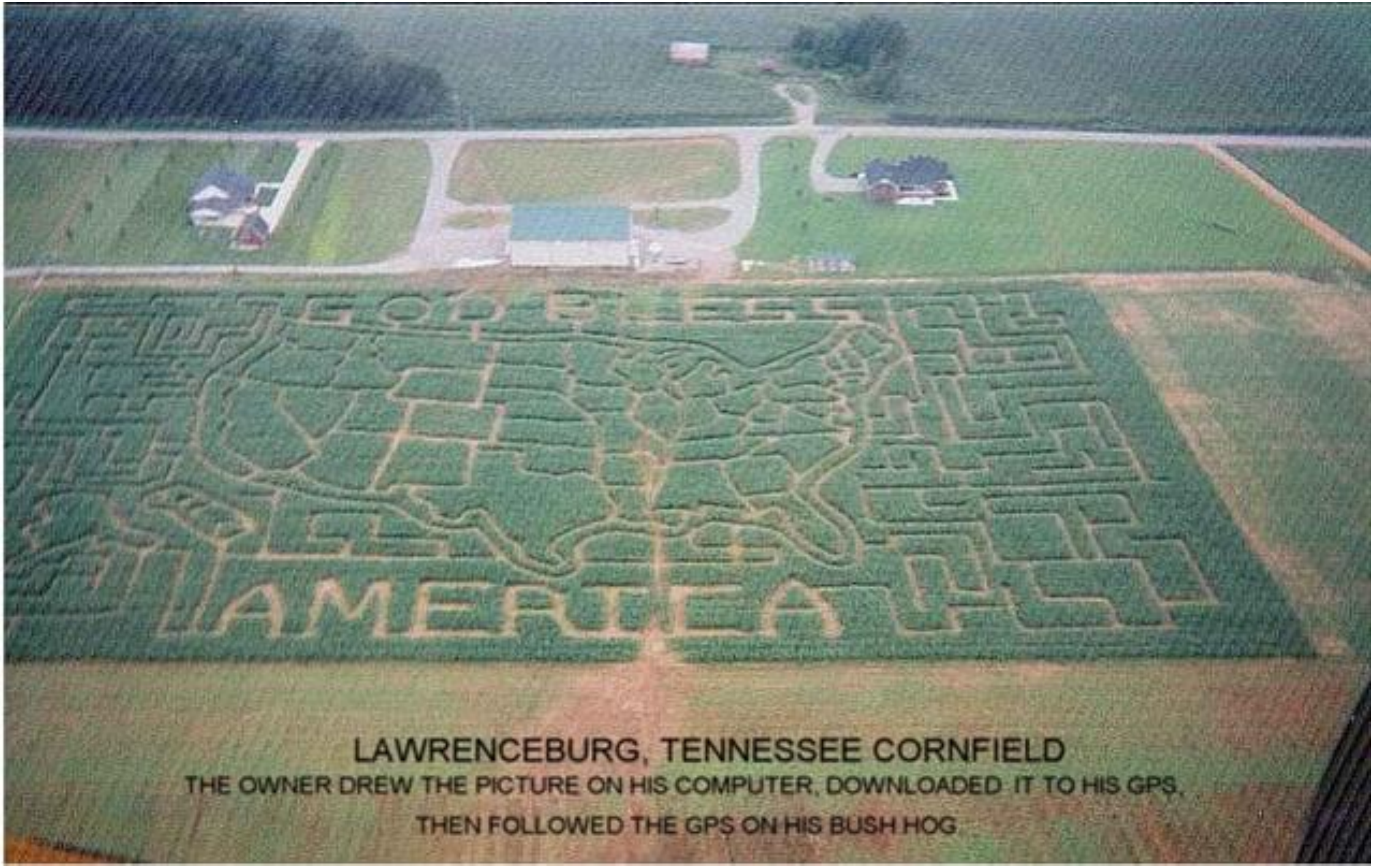
LIDAR images of Manhattan before and after 11 SEP 2001



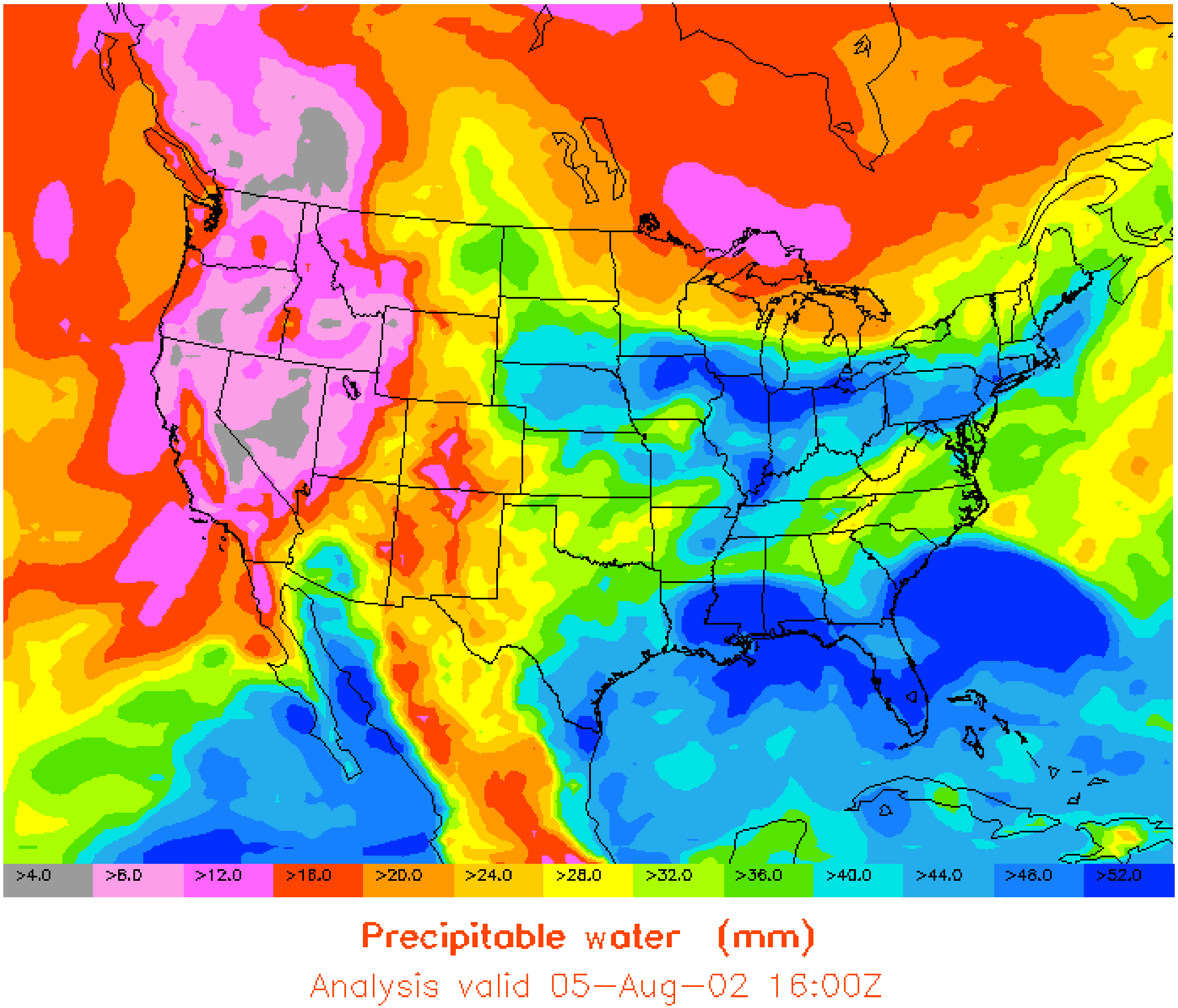
These images are computerized visualizations of elevation information of the World Trade Center from before (July 2000) and after (September 15, 2001) the attack. These maps were produced using an airborne LIDAR (Light Detection and Ranging) system. The LIDAR system creates detailed and highly accurate elevation information by the precise timing of thousands of laser pulses striking the ground surface. These data can be manipulated in the digital environment to create an array of maps and views of the project site and to obtain precise measurements of structures, debris fields, and other vital information. These images were generated by EarthData (www.earthdata.com), and the aircraft was positioned using CORS data from the NJI2 site which is operated by the New Jersey Institute of Technology.


Hurricane Katrina Base Map Index Page
Louisiana, Mississippi, & Alabama
Image Index Map
August 2005
All imagery provided by NOAA
Path of Katrina
Click boxes to zoom in and view image footprints.

Precision Agriculture



Hourly Forecast of Precipitable Water



NOAA/NGS Goal for Real-Time Positioning

Promote accurate and reliable real-time positioning services that are consistent with the National Spatial Reference System, whether these services are being provided by a public or commercial organization.

NOAA/NGS Support for Regional Real-Time GNSS Networks

I. STREAM RT OBSERVABLES VIA NTRIP FROM SELECTED FEDERALLY OWNED/OPERATED CORS. ULTIMATE USE OF "FOUNDATION" CORS. NO CORRECTORS. HELPS TO DENSIFY RTN AND ACTS AS FIDUCIAL VALUES.

II. DEVELOP GUIDELINES FOR USERS AND OPERATORS / ADMINISTRATORS OF RTN. SINGLE-BASE USER GUIDELINES IN DRAFT FORM. RTN OPERATOR GUIDELINES IN DRAFT FORM. RTN TEAMS/WORK GROUPS.

III. EDUCATION/OUTREACH AT ALL LEVELS: LOCAL/REGIONAL/NATIONAL/INTERNATIONAL. CONFERENCES AND COOPERATIVE EFFORTS. ADDRESS & RESOLVE RTN ISSUES.

IV. CONTINUE SCIENTIFIC RESEARCH & APPLICATION DEVELOPMENT OF PHENOMENA AFFECTING ACCURATE REAL-TIME POSITIONING. EXAMPLES: GEOID MODELS, GNSS ORBITS, CRUSTAL MOTION, ANTENNA CALIBRATION, MULTIPATH, REFRACTION.

NOAA/NGS Support for Regional Real Time Networks

- NOAA/NGS would publicly stream GNSS data (not correctors) via the Internet for ~ 200 federally-funded sites
- These sites may include elements of the NDGPS, WAAS, NOAA, and PBO networks
- Anticipated intersite spacing = 200 km in CONUS
- Regional real-time networks may use the NOAA/NGS-provided data to calibrate and/or enhance their services (which typically require an intersite spacing of about 50 km)
- If NOAA/NGS is to understand the intricacies of providing real-time data, then the agency needs to be intimately involved in the process
- These data are being federally funded (for other purposes), and they should be made publicly available for accurate real time positioning

I.

NGS Realtime GNSS: NTRIP Service

NGS Realtime GNSS Data Service

User Registration for NGS Realtime GNSS Data Service (Prototype)

Please complete this form to apply for free access to real-time GNSS data streams from the NGS NTRIP Caster at *realtime.ngs.noaa.gov* (port 2101).

User data (* mandatory): NGS privacy policy

Full Name* :

Organization* :

City* :

State/Country* : -- US states --

ZIP Code :(5 numbers, required only if country is US)

Phone :

E-mail* :

The login information you will receive by email in response to your request is only valid for your personal use.

DISCLAIMER

The NTRIP service being offered by NGS is in test and evaluation mode (prototype). NGS makes no claim, direct or implied, that the data streams will be uninterrupted, consistent or entire.

☐ I have read and accepted the disclaimer.

Send Registration Form | Clear This Form

National Geodetic Survey (NGS)
Maryland, U.S.A
ngs.realtime.gnss@noaa.gov

Date Last Updated: April 18, 2008

NOAA Privacy Policy NGS NTRIP Service Disclaimer

3.2 Message Type Summary

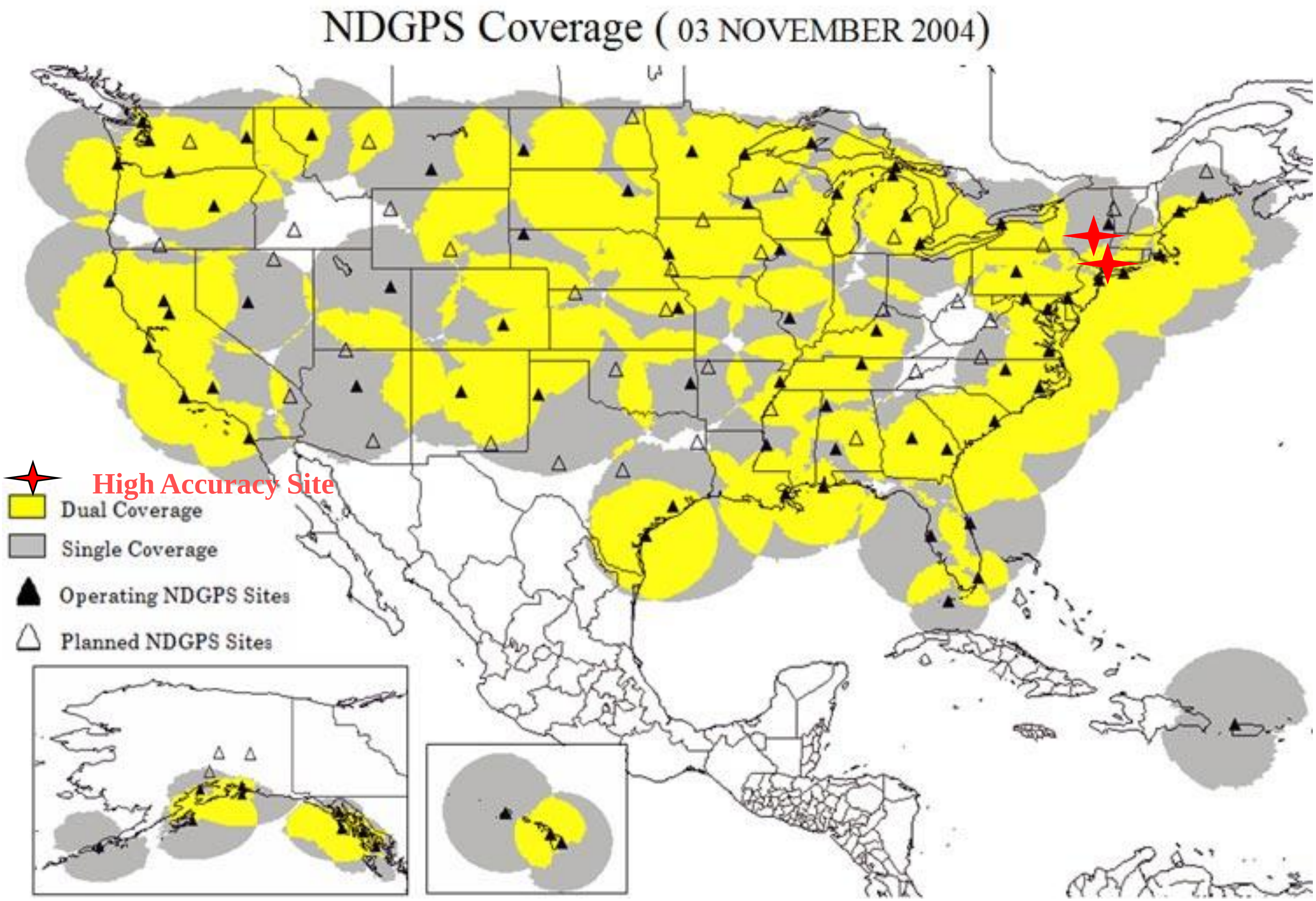
The message types shown in Table 3.2-1 support Real-Time Kinematic (RTK) individual and network broadcasts for GPS, GLONASS, .

Table 3.2-1. Message Type Table

Message Type	Message Name	No. of Bytes **	Notes
1001	L1-Onl		
1002	Extende		
1003	L1&L2		
1004	Extende		
1005	Stationa		
1006	Stationa with An		
1007	Antenna		
1008	Antenna		
1009	L1-Onl		
1010	Extende Observa		
1011	L1&L2		
1012	Extende Observa		
1013	System		
1014	Networl		

Message Type	Message Name	No. of Bytes **	Notes
1015	GPS Ionospheric Correction Differences	$9+3.75*N_s$	N_s = Number of Satellites
1016	GPS Geometric Correction Differences	$9+4.5*N_s$	N_s = Number of Satellites
1017	GPS Combined Geometric and Ionospheric Correction Differences	$9+6.625*N_s$	N_s = Number of Satellites
1018	RESERVED for Alternative Ionospheric Correction Difference Message		
1019	GPS Ephemerides	62	One message per satellite
1020	GLONASS Ephemerides	45	One message per satellite
1021	Helmert / Abridged Molodenski Transformation Parameters	51.5+N+M	N = Number of characters in Source Name M = Number of characters in Target Name
1022	Molodenski-Badekas Transformation Parameters	64.625+N+M	N = Number of characters in Source Name M = Number of characters in Target Name
1023	Residuals, Ellipsoidal Grid Representation	72.25	
1024	Residuals, Plane Grid Representation	73.75	
1025	Projection Parameters, Projection Types other than Lambert Conic Conformal (2 SP) and Oblique Mercator	24.5	
1026	Projection Parameters, Projection Type LCC2SP (Lambert Conic Conformal (2 SP))	29.25	
1027	Projection Parameters, Projection Type OM (Oblique Mercator)	32.25	

Nationwide Differential GPS Network



Wide Area Augmentation System (WAAS)

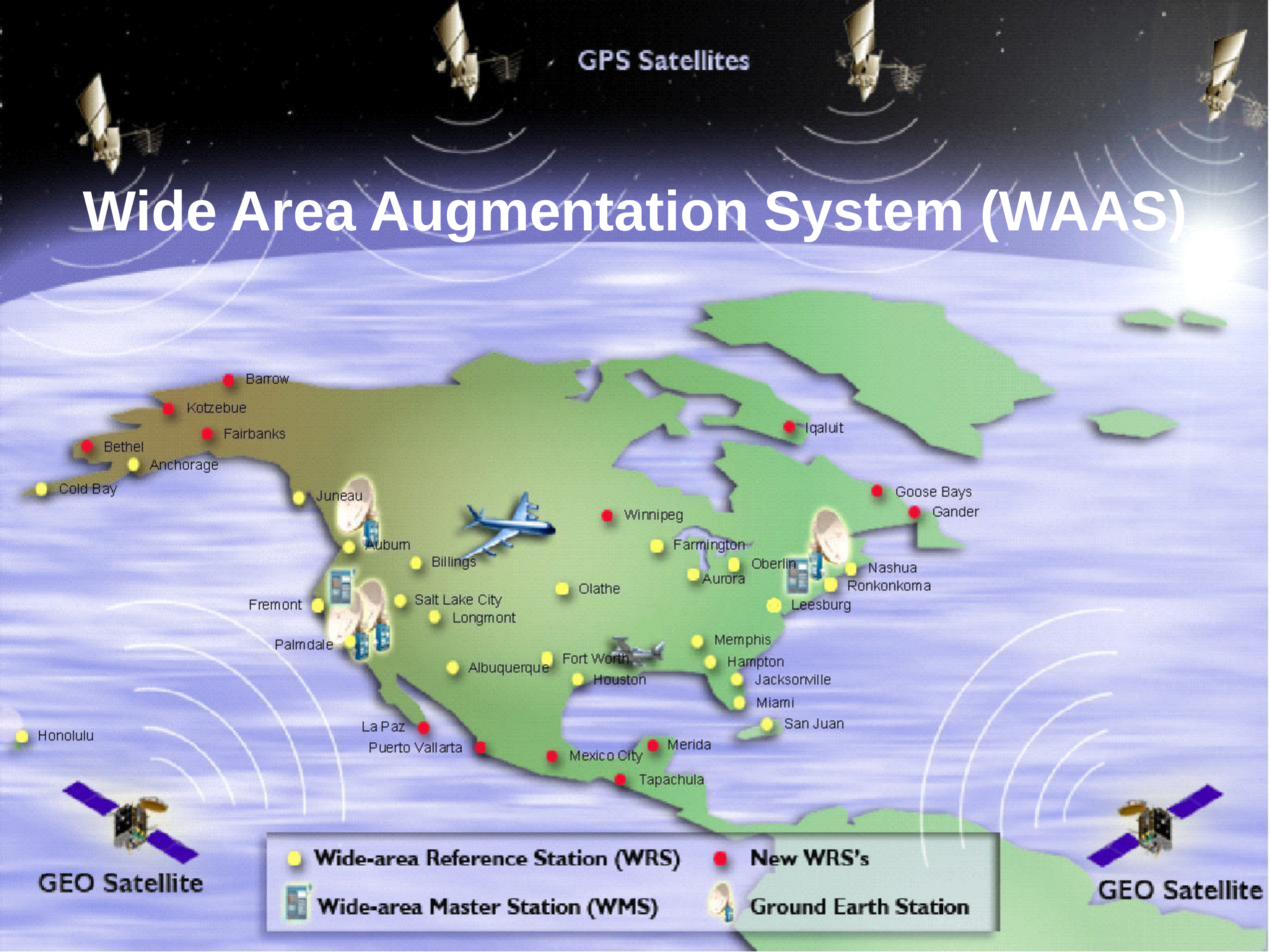


Plate Boundary Observatory

NOAA/NGS Support for Regional Real-Time Networks

- Collect, archive, and distribute selected GNSS data from regional real-time networks to support post-processing applications (Also, encourage network operators to do likewise)
- That is, NOAA/NGS would incorporate selected real-time sites into the traditional CORS network
- NOAA/NGS would NOT rebroadcast the GNSS data from regional networks in real time

A Special Application of Real-Time Data to Postprocessing

Immediately after a person has collected a couple hours of GNSS data at a single location, this person could submit these data to OPUS to obtain highly accurate positional coordinates for his/her location in minutes. This capability assumes the person has Internet access and that NGS receives a real-time data feed from a few CORS located near to the person's location.

Benefit: the person would know whether or not he/she observed suitable data before leaving the location.

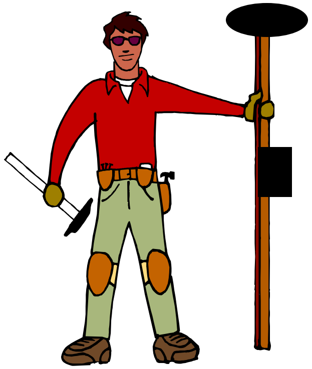
NOAA/NGS Support for Regional Real-Time Networks

NOAA/NGS would stream auxiliary information to the public via the Internet:

- Satellite ephemerides
- Satellite clock parameters
- Ionospheric models
- Tropospheric models

II. THE TWO DIRECTIONS OF REAL-TIME NETWORK POSITIONING

I. TOP DOWN: <u>Overall Administrator's viewpoint-</u> Alignment to the NSRS, coordinates, adjustments, Network spacing, Site requirements, Communication issues, Personnel, Cost/Benefit analysis, $$$$, Partners



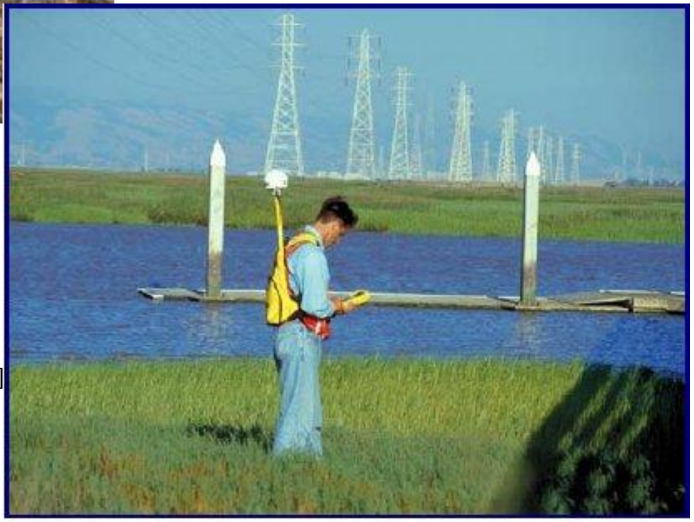
II. USER UP: <u>Best methods-</u> Field techniques, GNSS knowledge, Knowing datum requirements, Knowing accuracy requirements, Calibrations, Applications, Data management

II. RT POSITIONING GUIDELINES

- GUIDELINES, SPECS, STANDARDS
  √ SINGLE-BASE USER – DRAFT OUT
- RTN PLANNING & NETWORK DESIGN
- RTN CONSTRUCTION/SITE EVALUATION
- RTN ADMINISTRATIVE - FIRST DRAFT OUT
- RTN USER

RTN TEAM

RT POSITIONING - BEST METHODS

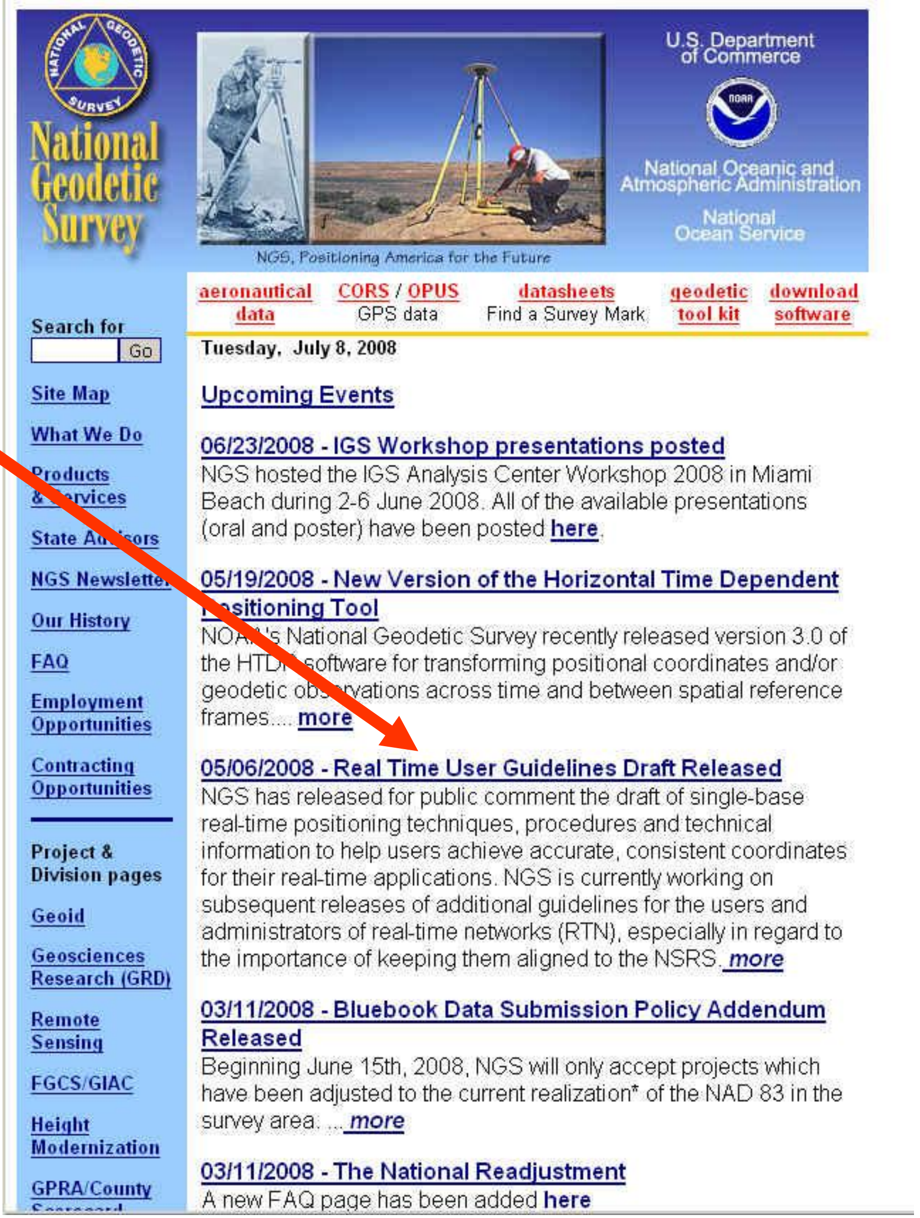


NATIONAL OCEANIC AND ATMOSPHERIC ADMINI

National Ocean Service

National Geodetic Survey

WWW.NGS.NOAA.GOV



WHY SINGLE-BASE?

-**ACCOMMODATE LEGACY USERS**

- **CLOSEST BASE NETWORKS**

-**AREAS WITH NO CELL COVERAGE**

- **PROJECT SITE APPLICATIONS, SUCH AS MACHINE CONTROL**

***WHY EMPIRICAL*?**

-**PLETHORA OF VARIABLES**

-**TIMELINESS**

-**PORT TO RTN USERS**

-**DYNAMIC NATURE OF RT POSITIONING**

NATIONAL GEODETIC SURVEY
USER GUIDELINES
FOR CLASSICAL
REAL TIME GNSS POSITIONING

DRAFT

v. 2.0.3 September 2008

William Henning, lead author

RT ISSUES – SUCH AS:

- ✓ **PDOP**
- ✓ **RMS**
- ✓ **# SVNS**
- ✓ **BASELINE LENGTH**
- ✓ **REDUNDANCY**
- ✓ **# BASES**
- ✓ **OBS TIMES**
- ✓ **EQUIPMENT**
- ✓ **LATENCY**
- ✓ **FIXED/FLOAT**
- ✓ **ELEVATION MASK**
- ✓ **LOCALIZATIONS**
- ✓**ACCURACY/PRECISION**
- ✓ **SPACE WEATHER**
- ✓ **GEOID QUALITY**
- ✓ **QA / QC**
- ✓**GPS / GLONASS**

- Multipath
- Position Dilution of Precision (PDOP)
- Baseline Root Mean Square (RMS)
- Number of satellites
- Elevation mask (or cut-off angle)
- Base accuracy- datum level, local level
- Base security
- Redundancy, redundancy, redundancy
- Part(s) Per Million Error (ppm) – iono, tropo models, orbit errors
- Space weather- sunspot numbers, solar maximum
- Geoid quality
- Site calibrations (a.k.a. Localizations)
- Bubble adjustment
- Latency, update rate
- Fixed and float solutions
- Accuracy versus Precision
- Signal to Noise Ratio (S/N or C/N0)
- Float and Fixed Solutions
- Carrier phase
- Code phase
- VHF/UHF radio communication
- CDMA/SIM/Cellular TCP/IP communication
-WGS 84 versus NAD 83, or other local datums
- GPS, GLONASS, Galileo, Compass Constellations

GUIDELINES FOR RTN OPERATORS

Chapter 1: Generating Coordinates for RTN Stations

Promote consistency of RTN-generated coordinates with current realizations of both the North American Datum of 1983 (NAD 83) and the International Terrestrial Reference System (ITRS).

Note that NAD 83 is the official spatial reference system for geometric positioning in the United States.

CURRENT REALIZATIONS OF ITRS AND NAD 83

For ITRS, NGS endorses ITRF2000 (= the International Terrestrial Reference Frame of 2000).

For NAD 83, NGS endorses:

* NAD 83 (CORS96) for use in CONUS, Alaska, Puerto Rico and the Virgin Islands
* NAD 83 (PACP00) for use in Hawaii, the Marshall Islands, American Samoa and other islands residing on the Pacific tectonic plate
* NAD 83 (MARP00) for use in Guam, Saipan, and other islands residing on the Mariana tectonic plate.

NOTE: NAD 83 (NSRS2007) is an approximation to NAD 83 (CORS 96).

CONSISTENCY BETWEEN ITRS AND NAD 83

Question: Can coordinates be consistent with both ITRS and NAD 83?

Answer: Yes, because NAD 83 (CORS96) is currently defined in terms of a 14-parameter Helmert transformation from ITRF2000.

Similarly, NAD 83 (PACP00) and NAD 83 (MARP00) are each defined in terms of a 14-parameter Helmert transformation from ITRF2000.

NOTE: These transformations are errorless because they are how the NAD 83 realizations are defined.

SUMMARY OF RECOMMENDATIONS

1. Some RTN stations should also be contained in the National CORS network.

2. For each RTN station, adopt values for its coordinates and velocity that are consistent with corresponding values adopted by NGS for stations in the CORS network.

3. For each RTN station, test for the continued consistency of its coordinates and velocity on a daily basis and revise the station’s adopted coordinates and/or velocity if the tests reveal a need to do so.

RECOMMENDATION 1: SOME RTN STATIONS SHOULD BE IN NATIONAL CORS NETWORK

- If RTN contains more than 30 stations, at least 10% should also be contained in the National CORS network.
- If RTN contains 30 or less stations, at least 3 RTN stations should also be contained in the National CORS network.
- NGS computes and published coordinates and velocities for all CORS; hence, those RTN stations included in the CORS network can serve as fiducial points for calculating coordinates for other RTN stations.
- NGS maintains high standards for stations in the CORS network.

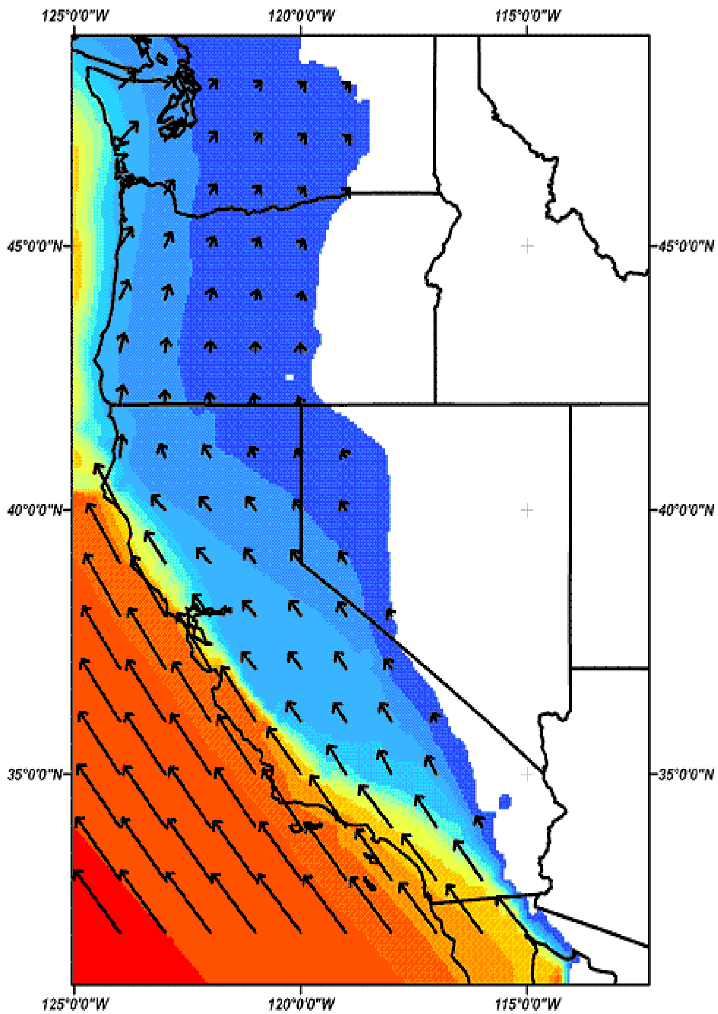
RECOMMENDATION 2: ADOPT RTN COORDINATES & VELOCITIES THAT ARE CONSISTENT WITH CORS COORDINATES & VELOCITIES

- Predicted RTN coordinates should agree with predicted CORS coordinates to within 2 cm in each horizontal dimension (north-south and east-west) and to within 4 cm in the vertical dimension (ellipsoid height).

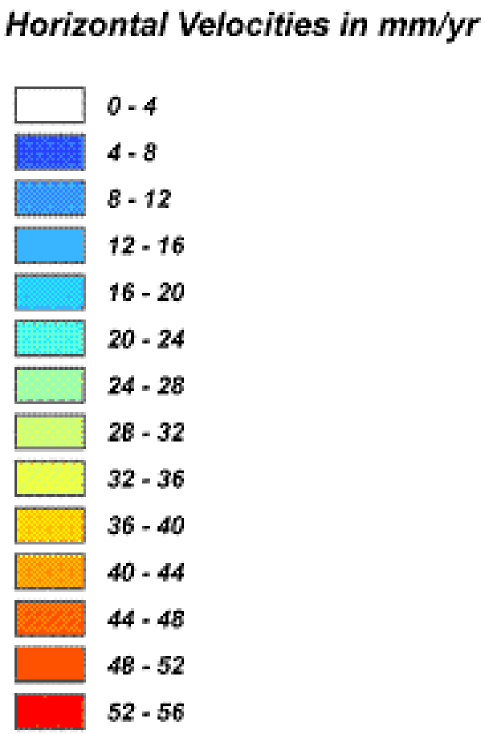
- RTN administrators should advise NGS of any problems they detect with NGS-adopted CORS coordinates.

- RTN coordinates may need to be more accurate than CORS coordinates so that RTN-generated correctors to GNSS observations will be as accurate as possible.

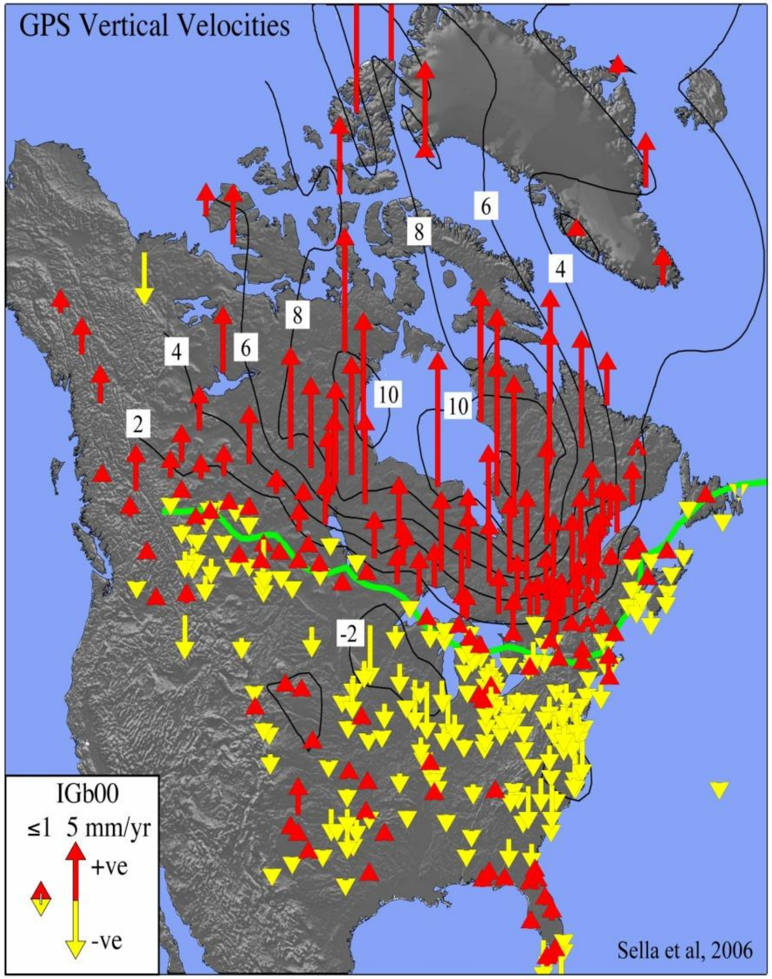
Horizontal Crustal Motion



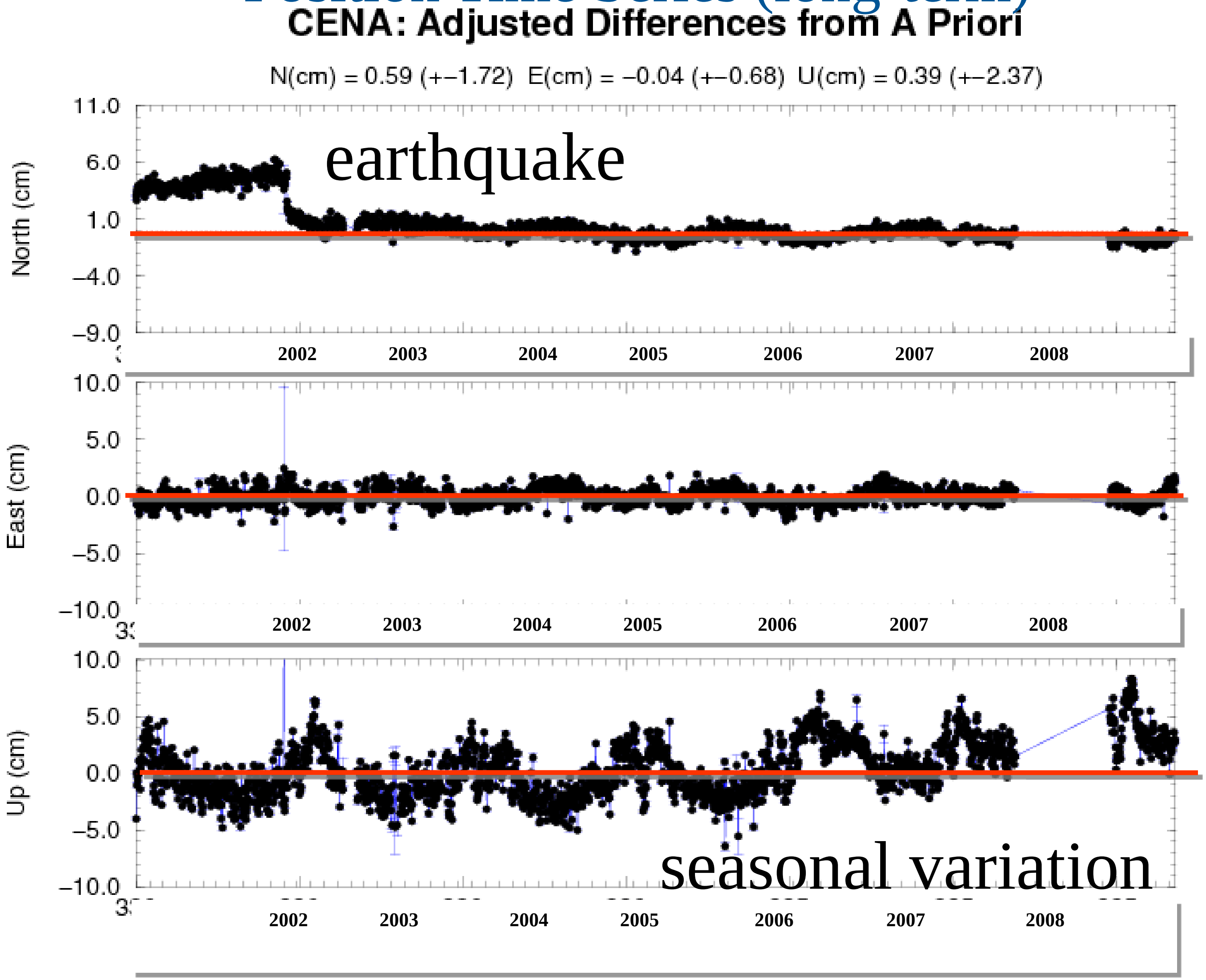
Horizontal velocities in the western U.S. relative to the North American Datum of 1983 as derived from geodetic observations.



Vertical Crustal Motion



Position Time Series (long-term)



RECOMMENDATION 3: TEST DAILY FOR THE CONTINUED CONSISTENCY OF RTN COORDINATES & VELOCITIES

- For each RTN station, the RTN administrator should submit a 24-hour GPS data set to OPUS for each day of operation.

- If, for several consecutive days, the multi-day average of the OPUS-generated coordinates differs from the RTN-predicted coordinates by more than 2 cm in a horizontal dimension and/or by more than 4 cm in the vertical dimension, then either revise the station's coordinates or advise NGS that there may be a problem with the coordinates for one of the CORS being used by OPUS.

- NOTE: OPUS allows its users to select the 3 CORS that this software will use. Hence, the RTN administrator can select CORS that are contained in his/her RTN.

Suggestions for Determining RTN Station Coordinates

Option 1: Submit 24 hours of GPS data from each station to OPUS for each of at least 10 days and compute the arithmetic mean of the daily OPUS-generated coordinates.

Option 2: Process at least 10 days of GPS data from all RTN stations using a simultaneous network adjustment while constraining several CORS coordinates with weights of 1 cm in each horizontal dimension and 2 cm in the vertical dimension.

NGS recommends Option 2.

Suggestions for Determining Velocities for RTN Stations

- Use the HTDP (Horizontal Time-Dependent Positioning) software to predict velocities for new RTN stations. (The predicted vertical velocity will be zero.)

- After 3 years, use GPS data from the RTN station to produce a time series of the station's coordinates, then use this time series to estimate a velocity for the RTN station.

RECAP OF RECOMMENDATIONS

1. Some RTN stations should also be contained in the National CORS network.

2. For each RTN station, adopt values for its coordinates and velocity that are consistent with corresponding values adopted by NGS for stations in the CORS network.

3. For each RTN station, test for the continued consistency of its coordinates and velocity on a daily basis and revise the station's adopted coordinates and/or velocity if the tests reveal a need to do so.

III. OUTREACH, COOPERATIVE EFFORTS AND LEADERSHIP

+ PUBLIC & PRIVATE *RTN ADMINISTRATORS* SPANNING MORE THAN 35 STATES

NOAA/NGS Support for Regional Real-Time Networks

- NOAA/NGS would study temporal variations in positions (seasonal, daily, ocean loading, atmospheric loading, subsidence, tectonic, etc.)
- NOAA/NGS would study phenomena affecting accurate positioning (satellite orbits, refraction, multipath, antenna calibration, geoid, etc.)

Not a Navigation Service

- It is important to realize that the regional real-time networks would not constitute a "navigation service" as defined by the U.S. Government, nor would the NOAA/NGS network. That is, these networks would not meet all "safety-of-life" requirements.
- These networks, however, would complement rigorous navigation services, such as the NDGPS and WAAS programs, by providing a 1 – 5 cm real-time positioning capability.